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(54) **COLLAPSIBLE MANDREL FOR  
MANUFACTURING THREE-DIMENSIONAL  
STRUCTURES**

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CPC ..... **B29C 33/448** (2013.01); **B29C 33/485**  
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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,282,734 A 2/1994 Pastureau et al.  
5,817,269 A \* 10/1998 Younie ..... B29C 33/38  
249/82  
7,588,655 B2 \* 9/2009 Pham ..... B29C 43/12  
156/227  
2009/0130442 A1 \* 5/2009 Christ ..... C01B 31/0423  
428/367  
2011/0304067 A1 12/2011 Rossfeldt et al.  
2012/0228467 A1 9/2012 Wallen et al.

FOREIGN PATENT DOCUMENTS

JP S5868446 A \* 4/1983 ..... B22C 1/02  
OTHER PUBLICATIONS

Kishi, et al; "Dismantlable Epoxy Adhesives for Recycling of Struc-  
tural Materials," 16th International Conference on Composite Mate-  
rials, ICCM-16—"A Giant Step Towards Environmental Awareness:  
From Green Composites to Aerospace," Kyoto; Jul. 8, 2007 through  
Jul. 13, 2007.

Gardos, et al; "Solid Lubricated Turbine Bearings: Part I—Prepara-  
tion of 316 degree C Lubricative Composites and Separators," ASLE  
Special Publication 1984, pp. 248-257, ASLE Proceedings—3rd  
International Conference on Solid Lubrication.

(Continued)

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(57) **ABSTRACT**

A mandrel for manufacturing a three-dimensional structure  
from a composite material. The external surface of the man-  
drel can at least partially correspond to the inner surface of the  
three-dimensional structure. The mandrel can include a plu-  
rality of expandable particles configured to increase respon-  
sive to a threshold condition. The mandrel can be configured  
to crack responsive to a triggering condition.

**20 Claims, 4 Drawing Sheets**

